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B-2 FIRE PROTECTION SYSTEM IN-FLOOR NOZZLE TRAFFICKING TEST

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This program evaluated the potential damage sustained by the B-2 fire protection system in-floor nozzle housing and cap when exposed to trafficking by a load cart placing loads on the housing similar to a fully loaded B-2 or munitions transporter. Two-hundred and fifty passes of a 25,000 pound, 250 psi load cart were applied to the nozzle housing and cap without damage to either. The pull-off force tests resulted in average pull-off forces that were well within the force produced by the activated fire suppression system. Painting the cap-container interface however, is not recommended.

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PREFACE

This report was prepared by the Wright Laboratory, Air Base Systems Branch, Fire Protection & Crash Rescue Systems Section, Tyndall Air Force Base, Florida 32403-5319.

Mr. James G. Murfee, WL/FIVCO, was the Project Officer. This test program was completed in support of ASC/YOC-OL. This report presents the results of the B-2 Fire Protection System In-Floor Nozzle Trafficking Test conducted from 24 August to 3 September 1992 at Tyndall AFB, Florida.

EXECUTIVE SUMMARY

A. OBJECTIVE

The overall objectives of this test series were to evaluate the potential damage sustained by the B-2 fire protection system nozzle housing and cap when exposed to trafficking by a load cart placing loads on the housing similar to a fully loaded B-2 aircraft or B-2 munitions transporter.

B. BACKGROUND

Due to the very high value of the new B-2 bomber, the U.S. Air Force designed a comprehensive in-floor hangar fire protection system that will rapidly detect and extinguish an in-hangar fire before measurable damage can occur to the aircraft. After automatic fire detection and system activation the system pumps Aqueous Film Forming Foam (AFFF) through in-floor nozzles, placed on 10-foot centers throughout the hangar floor. These nozzles are mounted in steel containers 11 inches in diameter and 12 inches deep set in the concrete floor. The housing cap is stainless steel 4 inch diameter and 1/4 inch thick, held into the housing by the friction of a rubber O-ring. This cap pops off during system activation due to the pressure of the AFFF from the nozzle. Some concern exists of the susceptibility of the cap to damage from the aircraft and various ground equipment tires, especially the heavy munitions transporter.

This test program evaluated the prototype in-floor nozzle housing for susceptibility to damage from trafficking by a fully loaded B-2 bomber and the munitions cart, both having similar footprint pressures (250 psi maximum).

C. SCOPE

This project evaluated the B-2 in-floor nozzle housing and cap for damage susceptibility from trafficking by a 25,000 pound load cart. A total of 250 passes of an F-15 loadcart loaded to 25,000 pounds were applied to the housing and cap. The F-15 loadcart was chosen due to its availability. The maximum load of 25,000 pounds and 250 psi tire were chosen as the worse case scenario, as these are the highest pressures and forces anticipated in the B-2 hangar environment.

D. CONCLUSION

The B-2 nozzle container is sufficiently designed for its intended purpose. No damage to the container or cap should be sustained by trafficking of the B-2 aircraft or munitions trailer. Pop-off forces for both clean and dirty systems are well within those produced by system activation. The system should be installed, as designed.

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SECTION I

INTRODUCTION

A. OBJECTIVES

The overall objectives of this test series were to evaluate the potential damage sustained by the B-2 fire protection system nozzle housing and cap when exposed to trafficking by a load cart placing loads on the housing similar to a fully loaded B-2 aircraft or B-2 munitions transporter.

Specific objectives were as follows:

1. Measure the maximum deflection of the center of the housing cap when loaded by a 250 psi tire.

2. Determine, by periodic visual inspections, any damage sustained by the housing cap and O-ring when exposed to 250 passes of a loadcart placing similar loads on the housing and cap as that of a fully loaded B-2 or munitions transporter.

3. Measure the force required to pop the cap off of the housing with a clean cap, with dirt in the cap/housing interface, and with the cap and housing top painted with epoxy paint.

B. BACKGROUND

Due to the very high value of the new B-2 bomber, the U.S. Air Force designed a comprehensive in-floor hangar fire protection system that will rapidly detect and extinguish an in-hangar fire before measurable damage can occur to the aircraft. After automatic fire detection and system activation the system pumps Aqueous Film-Forming Foam (AFFF) through in-floor nozzles, placed on 10-foot centers throughout the hangar floor. These nozzles are mounted in steel containers 11 inches in diameter and 12 inches deep set in the concrete floor (see Figure 1). The housing cap is stainless steel 4-inch diameter and 1/4-inch thick, held into the housing by the friction of a rubber O-ring. This cap pops off during system activation due to the pressure of the AFFF from the nozzle. There is some concern with the susceptibility of the cap to damage from the aircraft and various ground equipment tires, especially the heavy munitions transporter.

This test program evaluated the prototype in-floor nozzle housing for susceptibility to damage from trafficking by a fully loaded B-2 bomber and the munitions cart, both having similar footprint pressures (250 psi maximum).

C. MEASURES OF MERIT

1. The cap and housing should sustain no damage due to trafficking by 250 passes of a 25,000-pound load cart.

2. The pop-off cap should consistently release from its housing with no more than 10 pounds of vertical force.

D. SCOPE

This project evaluated the B-2 in-floor nozzle housing and cap for damage susceptibility from trafficking by a 25,000 pound load cart. The cylindrical steel housing was set in a 12-inch concrete section of the 9700 area rutting study test pad, Tyndall AFB, Florida. The steel housing was set in quick-set, high strength cement mortar, flush with the surface. A total of 250 passes of an F-15 loadcart loaded to 25,000 pounds and a tire pressure of 250 psi were applied to the housing and cap. A B-2 tire was not available for this test. Although the B-2 tire is much larger than that of the F-15, its maximum pressure is lower (215 psi). The B-2 munitions transporter, will also present an operational exposure to the nozzle housing and cap, and operates with a tire pressure of 250 psi. Hence, a tire pressure of 250 psi was chosen for the F-15 loadcart tire that was available, as a worst-case scenario. The 25,000 pound load was also chosen as the worse case scenario, as this is the maximum weight for the F-15 at an inflation pressure of 250 psi. The cap was visually inspected at intervals of 50 passes throughout the trafficking test. An X-Y strain gauge was attached to the lower side of the cap to measure maximum strain and deflection under load. A linear variable differential transformer (LVDT) was also used to directly measure vertical deflection.

E. AUTHORITY

HQ USAF Program Management Directive (PMD) Number 2132(15)/63723F (2104), 15 March 1991, Civil Engineering Technology, was the authority for this test. This test program was conducted as directed in the PMD and AFR 80-14.

F. TEST ITEM DESCRIPTION

The prototype nozzle housing for the B-2, in-floor hangar fire protection system is constructed from 6-inch cast iron pipe with an integral flange. The cover and pop-off cap are machined from stainless steel. The cap is retained by the friction of an O-ring seal along its lower edge. In its operational configuration, the fire-suppressing agent nozzle will be mounted in the center with the agent discharge just below the cap. Upon activation the pressure of the agent will displace the cap and apply agent to the under side of the aircraft. For this test, the nozzle was removed and instrumentation installed in its place to measure the strain and vertical deflection of the cap under load. A diagram of the test setup is shown in Figure 1.

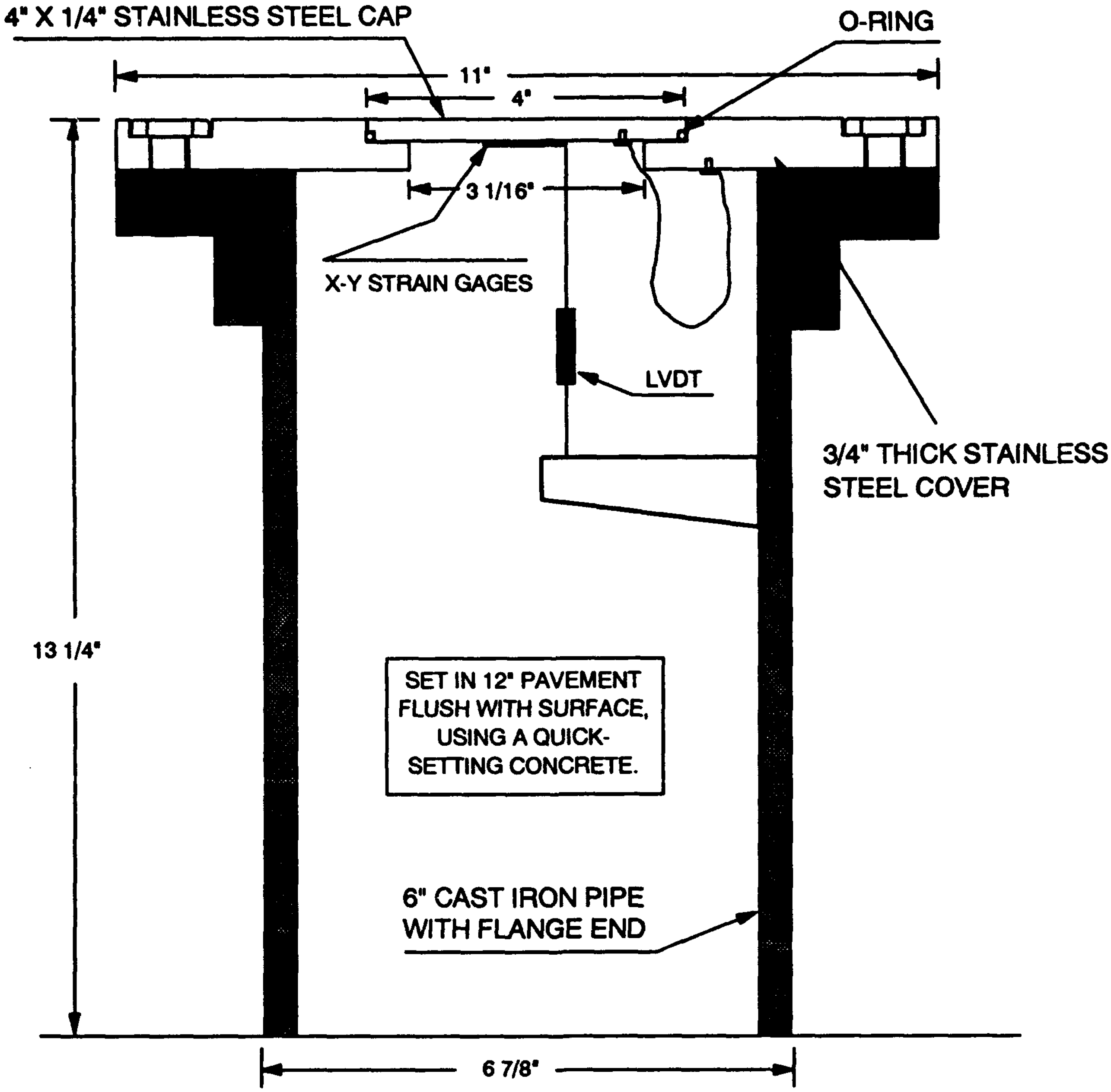

Figure 1. B-2 In-Floor Nozzle Housing Configuration

SECTION II

TEST DESCRIPTION

A. INTRODUCTION

This test evaluated the B-2 in-floor hangar fire protection system nozzle housing and cap for their susceptibility to damage when exposed to 250 passes of a 25,000 pound load cart. The cylindrical steel housing was installed in an existing concrete pavement test section at the 9700 area, Tyndall AFB, Florida, using a quick-setting concrete. The housing and lid were trafficked with an F-15 loadcart loaded to 25,000 pounds and 250 psi tire pressure. The deflection of the center of the cap was measured statically, under maximum load, and dynamically throughout the 250 loadcart passes, using strain gauges and an LVDT attached to the underside of the cap. The condition of the cap was visually inspected at 50-pass intervals throughout the loadcart passes. All tests were video recorded.

B. LOAD CART TESTS

The following procedures were accomplished to complete this test program.

1. An X-Y strain gauge set was installed on the center underside of the cap to permit the computation of the load deflection under maximum load from the load cart. An LVDT was also installed to directly measure the vertical deflection of the center of the cap.

2. An 8-inch diameter, 12-inch deep hole was cut into the selected concrete pavement section using a coring bit. A 12-inch square section, 3 inches deep and centered on the cored hole, was cut from the top of the concrete using a saw and jackhammer. The steel nozzle housing was installed in the pavement section, flush with the pavement surface, using a quick-setting concrete. Provisions were made for the necessary instrumentation wiring to be routed from the housing to the data collection system.

3. After the concrete was sufficiently set, the strain gauges, LVDT, and data collection system were set up and calibrated.

4. The load cart, configured with an F-15 tire inflated to 250 psi and loaded to 25,000 pounds, began trafficking the housing and cap with the wheel passing directly over the center of the cap. After the completion of 50 passes, trafficking was interrupted to inspect the housing and cap for damage. Trafficking resumed for 50 more passes with the loadcart tire displaced 2 inches from the cap centerline. Trafficking was again interrupted to inspect the housing and cap for damage. The remainder of the 250 passes was applied to the housing and cap with stops to inspect for damage at 50 pass intervals.

5. After the completion of 250 passes, the load cart tire was placed directly over the housing cap so as to place maximum load on the cap for a period of 15 minutes. The maximum deflection of the center was measured and recorded. The cap, O-ring, and housing were visually inspected for damage.

C. CAP TORSIONAL LOAD TEST

To simulate the torsional loads that may be experienced in the operational environment from turning vehicles, a 6,000-pound capacity forklift (100 psi tire pressure and a total tire weight of 3,550 pounds) was placed directly over the cap and the tire turned from side to side. Ten cycles were applied to the cap. The turning tire twisted the cap in the housing. Maximum strains and deflections were monitored and recorded.

D. CAP POP-OFF TESTS

These tests were accomplished after the completion of the load cart tests. A small stainless strap steel was epoxied to the top center of the cap. Using a pull scale, the cap pop-off force was measured first with the cap in its clean just installed, condition. A second test of the pop-off force was made with the cap and housing subjected to dirt and oil in the cap/housing interface similar to the conditions that might be encountered on a hangar floor. The Pop-off force with the cap painted in-place was not accomplished due to non-availability of the specific B-2 hangar floor paint. The pop-off force was the computed average of six iterations of the test.

E. INSTRUMENTATION AND DATA COLLECTION

1. Instrumentation. An X-Y strain gauge set was installed to the center lower side of the housing cap to record the maximum deflection of the cap under load. An LVDT was also attached to the lower center of the cap to directly measure vertical deflection.

2. Data Collection. Data were recorded on data collection sheets. A stationary video camera recorded all test activities. Still camera photographs were taken of selected events.

SECTION III

TEST RESULTS

A. GENERAL

This test program was conducted as described in Section II, Test Description. The results of each test series are presented in the following paragraphs. Test Data are contained in Table 1.

B. LOAD CART AND TORSIONAL LOAD TESTS

Load cart tests were conducted as described in Section II, paragraph B. Both cyclic and static load tests were completed. In addition, torsional, or twisting loads, were applied to the container cap using the steerable wheels of a forklift. The measured maximum stress, strain, and vertical deflection of the center of the container cap are shown in Table 1.

Table 1. B-2 NOZZLE HOUSING AND CAP LOADS AND VERTICAL DEFLECTION

	Ex STRAIN	Ey STRAIN	AVERAGE STRAIN	MEASURED DEFLECTION (MILS)	CALCULATED DEFLECTION (MILS)	MAXIMUM STRESS (psi)
	***** MICRO-STRAIN *****					
CYCLIC LOAD CART	750	1100	925	11	7.8	38,321
STATIC LOAD CART	320	510	415	10	3.5	17,193
TORSIONAL LOAD	75	300	188	7	1.5	7,768

Maximum strains were measured by an X-Y strain gauge set attached to the lower center of the cap. Average strain is the numerical average of the repeated X and Y strains. Measured deflection was as measured by an LVDT attached to the lower center of the cap. Calculated deflections were calculated after the test from the maximum strains by the equation below. Maximum Stress was calculated from the maximum average strain using the equation below.

<u>CALCULATED DEFLECTION (Wm)</u>:

$$Wm = \frac{(.080303 * a^2 * (Ex + Ey)/2)}{h}$$

WHERE: Wm = vertical deflection; a = plate thickness; h = plate radius; Ex= Maximum strain (x direction); Ey= Maximum strain (y direction)

<u>MAXIMUM STRESS (Sm)</u>:

$$Sm = \frac{\text{Average Strain x E}}{(1-v)}$$

WHERE: Sm = Maximum Stress
E = Youngs modulus (29×10^6 for stainless steel)
v = poison's ratio (0.3 for stainless steel)

C. CAP POP-OFF TESTS

Cap pop-off tests were completed after the load cart and forklift trafficking tests were completed. A small stainless steel strap eye was glued to the top center of the cap with epoxy glue. A small pull scale (fish scale) was attached to the strap eye with a short piece of nylon cord. A vertical pull was manually placed on the scale until the cap popped off. The maximum force required was manually recorded for six iterations of the test. The cap pulled smoothly out of the container without binding on all tests. The initial test required 10.5 pounds to remove the cap. The cap was replaced and the test repeated five additional times. Pull-off force varied from 5.0 to 10.5 pounds during these clean cap tests. Six additional pull-off tests were completed after dirt and sand were ground into the cap/container interface. Pull-off force varied between 6.0 and 10.5 pounds during these dirty pull-off tests. Average pop-off forces required were 7.2 pounds for the clean cap and 8.6 pounds for the dirty cap.

While the pop-off force tests were not conducted for the painted cap, as originally planned, it was felt that painting the cap/container interface would bond the cap to the container, making the pop-off force excessively high. Therefore painting the top of the cap and container is not recommended.

SECTION IV

SUMMARY AND CONCLUSIONS

A. SUMMARY

Both static and dynamic loadcart tests were conducted with a representative load and tire pressure. Two-hundred and fifty passes of a 25,000 pound loadcart were applied to the container and cap. These loads produced no permanent deformations in the cap or the container. Maximum stress was well below the yield strength of 95,000 psi for stainless steel. At no time during the loadcart or forklift trafficking tests was the cap dislodged from the container.

The pull-off force tests resulted in average pull-off forces required of 7.17 pounds and 8.58 pounds for a clean and dirty cap/container system. The force level is well within the force produced by the activated fire suppression system and therefore no problems should be encountered with the cap blowing off during system activation. However painting the cap/container interface is not recommended.

B. CONCLUSIONS

The B-2 nozzle container is sufficiently designed for its intended purpose. No damage to the container or cap should be sustained by trafficking of the B-2 aircraft or munitions trailer. Pop-off forces for both clean and dirty systems are well within those produced by system activation. The system should be installed, as designed.